LBA-Ecology Phase I Activities and Analysis

LBA ecological research activities and progress to date in Phase I and a brief analysis of perceived research gaps and potential future research needs are summarized here. The latter analysis incorporates guidance provided by an informal, external review of LBA-Ecology conducted in conjunction with the February, 2001, LBA-Ecology Science Team meeting. This information is provided as background for persons not familiar with activities to date in LBA-Ecology.

Land Cover and Land Use Change

In studies of Land Use and Cover Change, LBA scientists have ongoing projects measuring rates of land conversion and abandonment using both traditional (Landsat) and new (MODIS, IKONOS) remote sensing data sets. Projects on rates of conversion and abandonment cover the full Brazilian legal Amazon and much of the Ecuadorian Amazon. Researchers have used government census data within Brazil and in other countries to link land cover data and land use data. A number of richly described case study areas, with a particular emphasis on small-holder agriculture inform our understanding of land use systems. These case studies are providing the basis for development of quantitative models of land use change. New models have been developed.

The spatial distribution of LBA land use change studies is biased towards Rondônia and the Central Amazon. The southern portion of the Amazon region, including much of the so-called arc of deforestation has been underrepresented in LBA case studies. In Brazil's moist forest biome, there are large forested areas in Mato Grosso and Southern Pará that have been the foci of intense change. In many cases, this change has been dominated by large-scale investment and corporate development that is qualitatively different than the development in Rondônia and along the Trans-Amazon Highway. Forested ecosystems in these regions also differ from the forests to the north and west simply because they are likely to be more water-stressed during the dry season. Much, although not all, of LBA land-use model development has focused on small-holder decision making. Decision making by other land managers and external influences on land use decisions have received less emphasis.

From the perspective of land use change, LBA research has focused almost exclusively on the upland environment. Wetlands are heavily used by the local population in the Amazon region. The wetland and upland regions interact economically.

LBA research is making some progress understanding the extent of logging although the results are hotly debated. This is a lively and exciting area of research that will continue and probably expand into the second phase of LBA-Ecology; it will be informed by new work recently selected, and now being discussed with Brazil, for airborne remote sensing using U.S. aircraft. The effects of logging damage on ecosystem functions, and the effects that logging has on regrowth and fire danger, have not been well quantified to

date. Not all logging is alike and future studies must recognize differences in management approaches and forest types. LBA is poised to make a major contribution to our understanding of the overall impact of logging on Amazonian ecosystems.

LBA scientists have already generated future scenarios of regional development. This activity helps to maintain perspective for the more detailed studies and helps to generate hypotheses for future work. Incorporating the lessons learned from case study analyses into models of land use change at the regional scale is a challenge for future LBA research.

Carbon Dynamics

LBA scientists have identified signals of seasonal and interannual variability in the regional carbon cycle through analysis of models and the Advanced Very High Resolution Radiometer (AVHRR) record of nearly two decades. Observations using the Moderate Resolution Imaging Spectrometer (MODIS) should soon provide a picture of seasonal variability and help to identify the components of interannual variability over the next few years. Recent results with atmospheric inversion models admit the possibility of strong interannual variation in flux of carbon from the Amazon region. Regional scale ecological models driven by meteorological and/or satellite vegetation index data show that interannual weather variations can generate a strong signal in the carbon balance of the Amazon region. This result has not been confirmed by observations.

Future progress in regional modeling depends upon improvements both in the models and in the data sets that feed the models. Many modeling and synthesis groups are working with the same basic biophysical data that was available at the beginning of LBA. While there have been refinements, basic soil and vegetation properties are based on RADAMBRASIL and other early studies. These data are valuable but opportunities exist to modify regional databases with information from detailed state and municipality level surveys. Access to the Rondônia State PLANAFLORA database is already yielding valuable results. Better soil maps, particularly with a variable for total soil plant available water by depth would provide a critical input to regional models. Improved spatial data on vegetation structure, biomass, and phenology would also be very helpful.

Implicit to LBA's research questions on carbon cycling, is the control of primary productivity by water availability. Even before LBA, research from Amazon forests showed both diel and seasonal fluctuations in carbon assimilation that related to moisture availability. Unfortunately current work has not isolated the mechanism for afternoon photosynthetic depression and lower daily assimilation in the dry season for Amazon forests. Water availability is the likely explanation for both effects. But, we do not know whether the main resistance to water movement is in the soils, the roots, or the stems of trees. Better understanding of mechanisms controlling both carbon and water budgets is critical to development of realistic models.

Process studies of carbon dynamics are critical for building better models in the future. LBA scientists are gathering essential new data on nearly all compartments in forest carbon cycling including roots, litter (coarse and fine), and woody growth and decomposition. As always, studies of underground components and processes are scarce. Much of the process research is concentrated at the Brasília, Manaus and Santarém sites, particularly in primary forests. Additional process research in carbon dynamics at other sites along the LBA transects would greatly strengthen the LBA program.

NASA is currently sponsoring tower based eddy covariance flux studies at LBA's Santarém site in undisturbed forest, logged forest, and pasture. It has become increasingly clear that tower-based carbon flux estimates are subject to considerable uncertainties during nighttime in the tropical forest environment in the Amazon. Nighttime respiration fluxes may be underestimated by the eddy covariance technique. Preliminary analysis suggests that simply filtering data to include only the most turbulent nighttime periods may not provide a solution to this problem as it has in other ecosystems. Some studies that will complement and check tower based flux estimates are underway at the Santarém sites and other LBA flux tower sites. However, LBA still requires innovative tests and improvements in eddy covariance approaches.

Carbon studies in LBA include substantial work in secondary forests and pasture lands but are fairly limited in cropping systems, logged areas, and areas experiencing fires. Ground fires remain difficult to detect and their regional effect remains to be quantified.

As is the case for land use studies, LBA carbon cycling studies are concentrated in the central Amazon of Brazil. Complementary research in transitional forests in the arc of deforestation in the states of Mato Grosso and Pará and in the most humid forested areas in Northwest Amazônia would fortify the LBA transect concept.

Trace Gases and Aerosols

Trace gas and aerosol studies are focused on illuminating processes and reducing uncertainty, rather than producing definitive budgets. LBA-Ecology efforts are strongly complemented by those of Brazilian- and European-sponsored atmospheric chemistry research in LBA, particularly in aerosols and reactive gases. Trace gas studies in LBA-Ecology are mainly concentrated in Rondônia, Santarém, and Brasília. The insights gained at these sites should help to constrain annual budget estimates as well as the role of management practices. Once again, the spatial concentration of studies has limited the types of land use studied. As in other areas of LBA-Ecology, studies of trace gases in wetlands have been underemphasized.

Studies of volatile organic carbon compounds (VOC's) by LBA-Ecology investigators and their Brazilian and European partners have produced useful preliminary surveys. In general, the work supports the global emission estimates that were developed in the 1990's. VOC emissions may be significant to carbon balance in some cases. However, volatile carbon emissions may be balanced somewhat by deposition of organic acids and aldehydes.

Nutrient Dynamics and Surface Water Chemistry

As might be expected because of the time required for nutrient analyses and for experimental manipulations, the results of nutrient dynamics studies in LBA are coming out rather gradually. These usual problems have been compounded by the difficulties encountered in the export of samples. Several LBA-Ecology groups have either delayed their work or reprogrammed for analysis within Brazil. The vast majority of LBA-Ecology samples of soil, vegetation, water, and gases are already analyzed in Brazil. Future studies should severely limit dependencies on sample export. Strengthening Brazilian laboratory capacities may be necessary in some cases for the efficient completion of LBA-Ecology studies.

Nutrient cycling studies in LBA-Ecology have focused on pastures and secondary forests with less emphasis on croplands. While the latter only cover a small area, they may have more intense nutrient effects. Intensive agriculture is more common in the southeastern portion of the Brazilian Amazon region.

For both local and mesoscale basins, there are now strong indications that changing land use has a significant impact on surface water chemistry. There is no strong indication related to surface water quantity and flow patterns because to date there have been insufficient linkages between surface hydrology work and chemical work in LBA. Are the changes in surface water chemistry important regionally? What are the effects of extensive wetlands on the procession of nutrients and carbon downstream? What are the linkages between river corridors, temporarily inundated or saturated areas, and carbon dynamics?